SERC 2011 ANNUAL REPORT

SYSTEMS ENGINEERING
Research Center

A US Department of Defense University Affiliated Research Center

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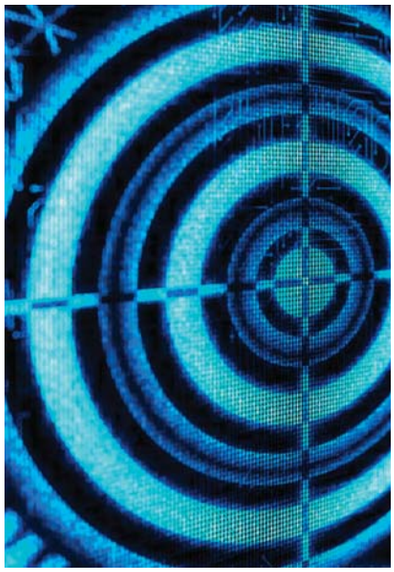
Aiming for Impact



2011 ANNUAL REPORT

CONTENTS

Impact. Change. A measurable effect. From its inception, the SERC was intended to demonstrably improve the development, integration, testing and sustainability of complex systems, services, and enterprises through better systems engineering. The SERC established collaborative relationships, built infrastructure, gathered intellectual and supporting capital, and executed research tasks aimed at improving systems engineering. After only three years, the impact of SERC research is beginning to materialize. Improved understanding of systems engineering as a discipline and innovations in education of the SE workforce are being adopted. New tools and methods are being developed and piloted. However, it is not enough.

Our sponsor's challenges are evolving as fast as the world itself. The imperatives and priorities identify real problems that require accelerated solutions that involve fundamental changes in systems engineering, as well as specific techniques and approaches tailored to the defense environment.

ASD(R&E) Research and Engineering Imperatives

1. Accelerate delivery of technical capabilities to win the current fight.
2. Prepare for an uncertain future.
3. Reduce the cost, acquisition time and risk of our major defense acquisition programs.
4. Develop world-class science, technology, engineering, and mathematics capabilities for the DoD and the Nation.

To meet the issues leading from our early experience, and extend the capabilities of the SERC to address national and global needs, we–our sponsors, leaders, and researchers–have collaboratively sharpened our vision to aim more precisely at achieving the desired outcomes.

The SERC Vision:

The networked national resource to further systems research and its impact on issues of national and global significance.

Or, more to the point, the SERC will be "The Systems Research and Impact Network."

We want to be assured that our talents result in the original intent: create and validate new methods, processes and tools (MPT), ensure they are in use, and improve effectiveness of systems engineering activities. This requires more than new ideas and initial development. It requires recognition that a particular tool or template in fact applies. It requires transition strategies, including evolution and training, to help practitioners apply the new capabilities to their project's benefit, and in turn, incorporating these lessons into the MPTs. Impact must be measured and so unbiased feedback mechanisms must be created and deployed. Only when these occur can we clearly show the ultimate return on investment – a solved problem, a capable and talented engineering workforce, and an effective and efficient defense acquisition system. These must be key outcomes of SERC contributions in the coming years.

Impact. Change. A measurable effect. Our vision sharpened and our aim precise. We are evolving our operational and research strategies. We are expanding our infrastructure and intellectual resources. We are growing. We invite you to work with us to achieve our vision.

Office of Secretary of Defense Science & Technology Priorities

Complex Threats

- Electronic Warfare / Electronic Protection
- Cyber Science and Technology
- Counter Weapons of Mass Destruction

Force Multipliers

- Data-to-Decisions
- Human Systems
- Autonomy
- Engineered Resilient Systems

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SYSTEMS ENGINEERING
Research Center

Director's Message

Dr. Dinesh Verma
Director,
Systems Engineering
Research Center

Welcome to the Systems Engineering Research Center (SERC) 2011 Annual Report. The SERC, competitively awarded by the Department of Defense to Stevens Institute of Technology in 2008, has grown to 22 collaborating institutions, over 20 research activities, and as we go to print, we have our 299th researcher. We welcomed the U.S. Army and U.S. Air Force as new strategic sponsors. In our third year, we are starting to see the impact of our research on the systems engineering community.

The SERC engaged on an important endeavor this year to refine our vision, reflecting the dramatically evolving landscape of DoD science and technology priorities. We are exploring engineering transformation, security from a systems perspective, systems of systems and enterprise modeling, risk assessment techniques, and workforce development. We are also maturing our operational strategies and support systems to evolve the SERC into a national and global resource.

To tackle these priorities requires us to strengthen our network. It is both a challenge and a reward to bring together multiple universities and facilitate opportunities for faculty and students to engage in impactful research. We are working to deepen our relationships with our collaborators, expand our work with sponsors, and go beyond research and into transition.

The SERC needs meaningful and sustainable research to stimulate innovation and continuously share and build upon findings. For example, the 3rd Annual SERC Research Review featured PhDs with the best systems engineering dissertation research from SERC projects, and we would like to see more success stories like these.

I thank the Department of Defense and our other sponsors for their continued and enthusiastic sponsorship of the SERC. We appreciate the trust they have placed in us to address their most pressing and important research challenges. I thank our collaborators and researchers for joining us in this endeavor.

Welcome from Stevens' President

Dr. Nariman Farvardin
President,
Stevens Institute of Technology

The SERC's new vision captures the importance of creating a networked resource of talent and capability to solve the challenges faced by an increasingly complex world. Targeted, innovative, impactful research is critical to how our nation acquires and engineers complex systems and creates an efficient and effective 21st century systems engineering workforce prepared to meet these challenges.

As the new President of Stevens Institute of Technology, I am proud to engage with the Department of Defense and be partnered with our collaborator universities, our esteemed research council, and our many sponsors in this endeavor. The SERC's research will impact our national interests, as well as countries and people around the world.

SERC Welcomes U.S. Army as New Strategic Sponsor

On April 18, 2011, the SERC signed a Cooperative Research and Development Agreement (CRADA) with the U.S. Army Research Development and Engineering Command (RDECOM). The CRADA provides a framework for a robust and collaborative research program between the SERC and the US Army to develop systems engineering models, methods, principles and practices for the complex systems under development and in use by the Army. The research will result in state-of-the-art capability and support to the Warfighter.

"RDECOM's mission is to get the right technology to the right place at the right time for the Warfighter. The Army can now collaborate with the intellect and capability of the SERC institutions to develop, validate, and facilitate the employment of new systems engineering skills."

Maj. Gen. Nick Justice, *Commanding General,*
U.S. Army Research Development and Engineering Command (RDECOM)

New Strategies for a New Vision

In its first three years of operations, the SERC community has conducted innovative research, broadened the sponsor base, and is beginning to see impacts from its work in improving defense systems engineering. This experience provides an opportunity to envision a SERC future of impact and sustainability, and undergirds the strategies that are necessary to reach it. In August, the SERC leadership team held a Strategic Offsite facilitated by SERC Advisory Board Chair, the Honorable Michael W. Wynne to outline a new vision. The results were presented to the SERC Advisory Board and the SERC sponsors in September, and in October a revised version was unveiled at the Annual SERC Research Review for feedback and refinement from SERC collaborators.

This visioning process, involving a wide and diverse community, led to unanimous support and approval for SERC's vision to be:

The Networked National Resource to further systems research and its impact on issues of national and global significance

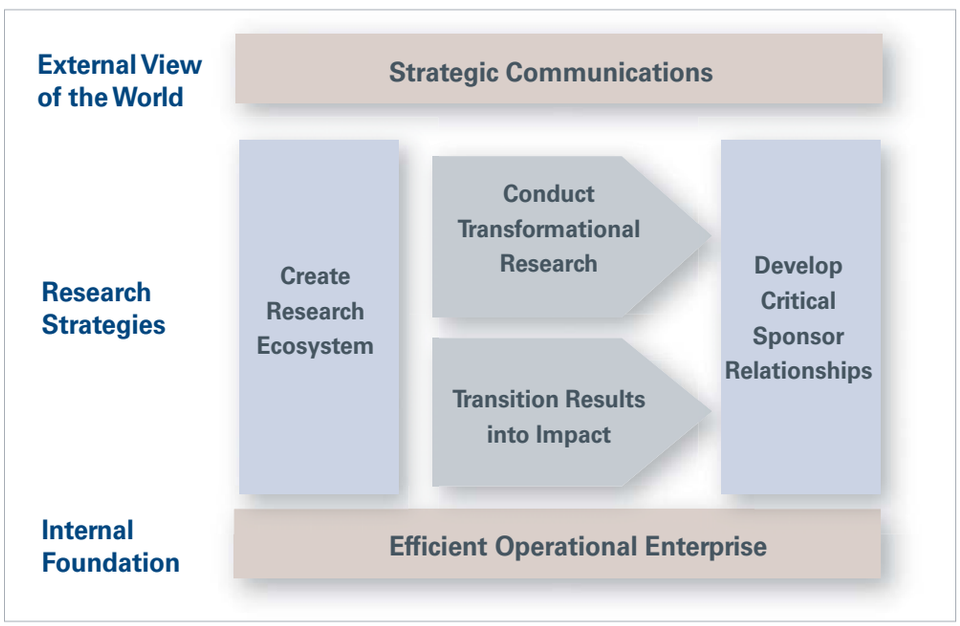
Each element of this vision is essential. The SERC must be **Networked** - a much stronger and vibrant statement than a collaboration. It forms an evolving, self-sustaining ecosystem, where the whole is far greater than the sum of the parts. The breadth of the network creates a **National Resource** for systems research, the natural first point of reference for anyone with systems challenges. The SERC focuses on **Systems Research**, a concept broader than traditional Systems Engineering. The critical systems challenges that face our nation involve enterprises, systems of systems, and include non-technical aspects such as social, economic and political factors. The SERC is first and foremost concerned with the **Impact** of its work. Success is measured by demonstrable effect, not just publications and tools, and the SERC plays an active role in creating the path to impact. Finally, the SERC is expected to focus its efforts on **Issues of National & Global Significance**; significant problems where solutions can improve quality of life throughout the world.

While visions are critical by providing inspiration and guidance to an organization and community, their realization requires strategy. Thought and care must be taken in defining and linking SERC objectives, metrics for success, key leverage points, supporting strategies, and creating a set of supporting initiatives and activities. As shown, SERC leadership developed framework for these linkages, inspired by work done by the Tennenbaum Institute at Georgia Tech.

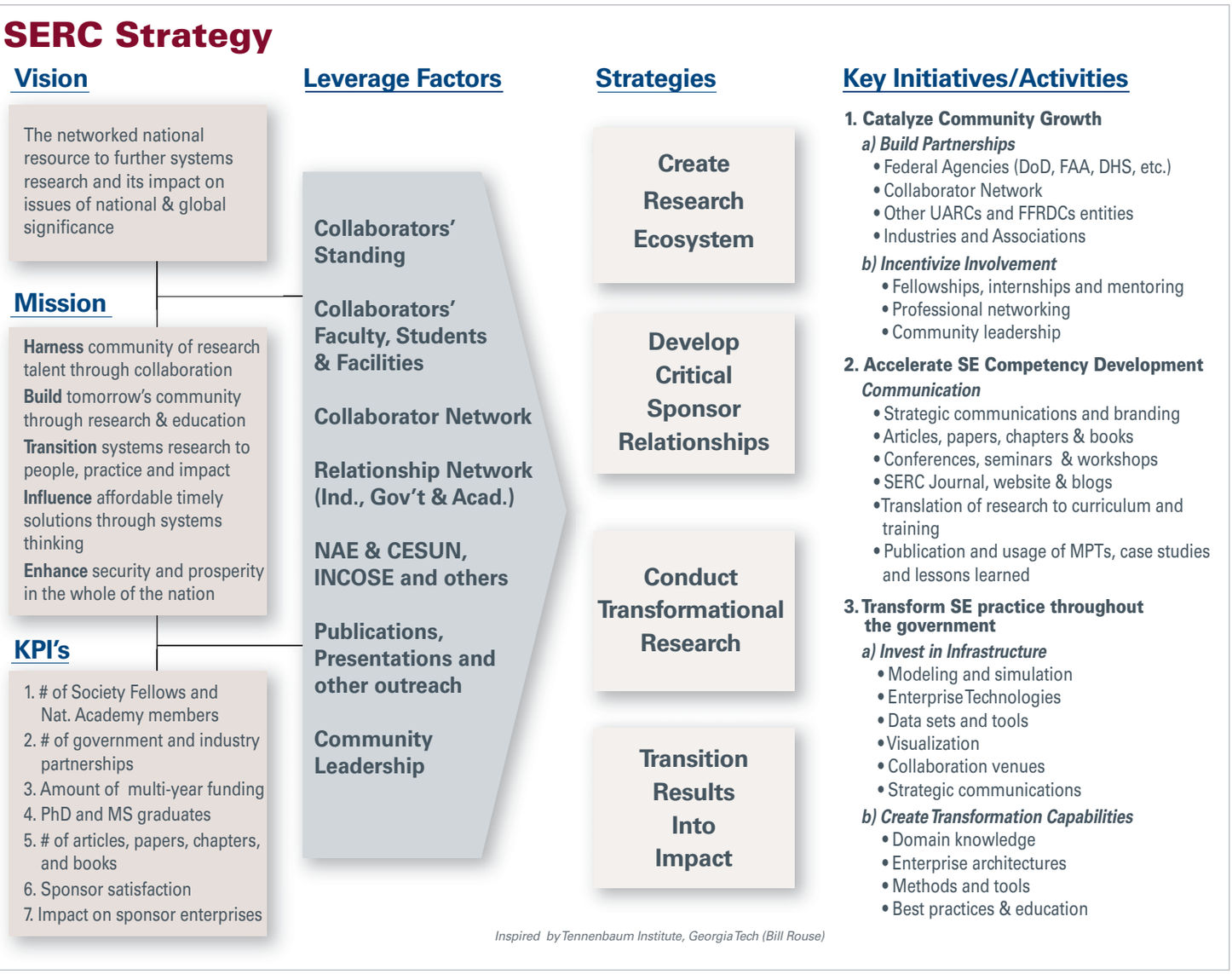
The SERC's objectives, a number of actions and results, enable the vision. First amongst these is the need to **Harness** systems research talent through networked collaboration. The systems challenges we face require the best and brightest capabilities from across our nation. Such a network must be based on trust and mutual benefit throughout the research community. Second, SERC actions must **Build** tomorrow's community through both research and education. The field of systems research is relatively young and SERC must focus on creating a solid foundation of knowledge and educational capabilities to enable long-term development. Achieving the desired impact means achieving successful **Transition** of systems research to people, process, technology, practice and impact. This extends the network of relationships to policy makers and practitioners within government and industry. The SERC can be an advisory body to **Influence** cost-conscious, timely solutions through systems thinking and practices, and act as the trusted independent voice to support appropriate and consistent decisions regarding our nation's critical systems challenges. Ultimately, the SERC should be a contributor to solutions that **Enhance** security and prosperity in the national and global community.

Each element of this vision is essential. The SERC must be Networked - a much stronger and vibrant statement than a collaboration. It forms an evolving, self-sustaining ecosystem, where the whole is far greater than the sum of the parts.

A number of Key Performance Indicators (KPIs) have been created to measure the SERC's progress toward achieving these objectives. The KPIs are intended to be few in number, and provide a reasonable and transparent way to track the SERC's success. They are an important element of the SERC's management plan and are thus embedded as metrics in its operational success.



SERC Strategy



Inspired by Tennenbaum Institute, Georgia Tech (Bill Rouse)

The SERC's major strengths involve the individual capabilities of its collaborative research institutions and the network that effectively magnifies the value of the community.

The coupling of vision and objectives with the leverage factors results in **four major strategies** and **two enabling objectives** as shown.

To provide the scaling and longevity necessary to support the SERC vision of becoming a National Resource, and to create a collaborative research network requires the creation of an organization with similar characteristics. The following set of four Operating Principles have been formulated to guide the behavior of the SERC on a day to day basis:

1. Do innovative, high-impact research, focusing on work that

- Increases the SE knowledge base through publication
- Can be generalized beyond a given domain thus transforming the discipline
- Has the potential of increasing the security and prosperity of the Nation
- Addresses future needs

2. Don't stop at proof-of-principle prototypes

- Work to ensure that there is a path from research results to impact

3. Grow and exploit the research network

- Ensure that the research is conducted by the best available resources
- Bring in new collaborators who provide long-term strategic benefit
- Focus on creating a network of academics, industry and government that is sustainable

4. Educate the next generation

- Provide a focus on education and training research, both in research (graduate students) and practitioners

The SERC community is proud of this vision and believes the enabling framework puts the SERC on sound footing for sustainable success conducting research, transitioning capabilities, and improving practice. We also believe that with this success, the SERC will provide an unparalleled impact on creating systems to meet our national and global challenges.

SERC Operational Accomplishments

In 2011, the SERC completed its third year of operations, continuing to grow and mature for greater impact:

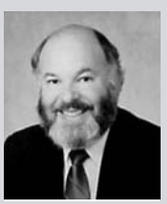
- To reflect the broad impact the SERC research network offers DoD and the nation, the SERC adopted a revised vision and supporting strategy (see pages 2 and 3).
- Mid-year, the Deputy Assistant Secretary of Defense for Systems Engineering became the primary SERC sponsor, better positioning the SERC to serve all of DoD.
- Total awards for new research activities rose slightly from $7.2M in 2010 to $8.4M in 2011 despite the many budget challenges our sponsors faced.
- SERC collaborators worked on 21 research activities in 2011, with over 50% on projects of greater than $500,000 and one year duration, reflecting the sponsors' confidence in the research quality and pace, and supporting the shift from smaller, shorter duration research tasks to larger, longer term tasks central to the SERC's high-impact research strategy.
- Two new strategic sponsors joined the SERC "family" - the Army's Research, Development, and Engineering Command (see page 1) and the Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering (page 7).
- SERC publications in journals and conference proceedings increased by 123% over 2010, indicating the maturing portfolio of SERC research.
- SERC benefitted from the high-caliber of its researchers, as 16 members of the National Academy of Engineering or Fellows of major professional societies participated in 2011 research projects.
- 239 faculty and students participated in 2011 research tasks, indicating the breadth of talent in the SERC network.
- The SERC network of collaborating universities continued to strategically expand, with the addition of Georgetown University and North Carolina Agriculture and Technical State University in early 2012.

Dr. Art Pyster
Deputy Executive Director

Ms. Doris Schultz
Director of Operations

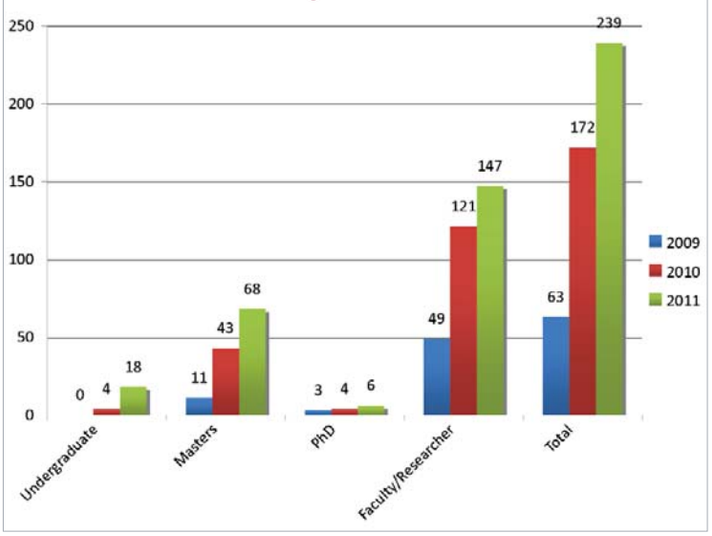
New SERC Directors

Ms. Debra Facktor Lepore
SERC Director of Strategic Programs



Dr. Stan Rifkin
SERC Director of Technical Programs

SERC researcher community grew to include increasing number of students

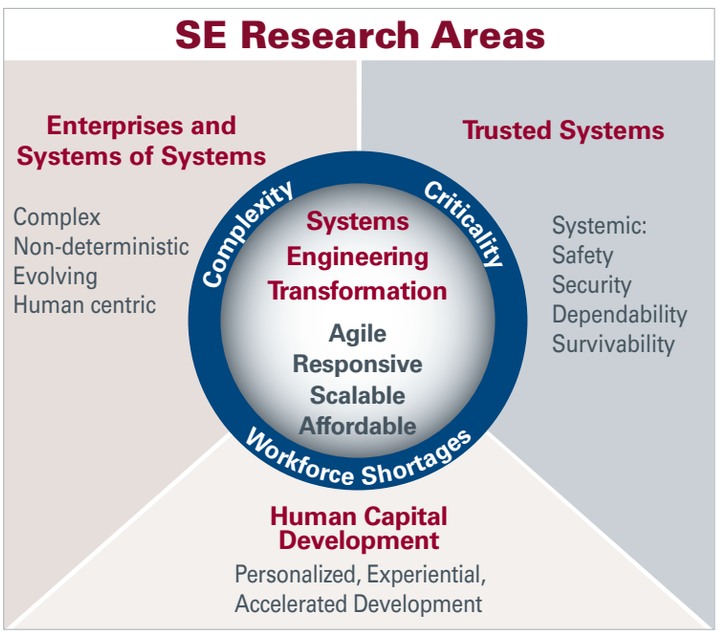


Summary - January 1 to December 31 ($000)

	2008	2009	2010	2011
Intel. Comm.	$346	$1,478	$1,017	$1,117
DASD (SE)	$494	$1,146	$4,291	$4,606
DAU	–	$430	$800	$1,239
Air Force	–	$180	$218	$690
Army	–	–	$910	$720
Navy	–	$250	–	–
Other	–	$78	–	–
TOTAL	$840	$3,562	$7,236	$8,372
# of Research Activities	2	11	18	21

An Evolving Role for the SERC Research Council

The Research Council, established in September 2010, played a critical role in guiding the evolution of the SERC research strategy. It was fundamental in framing the supporting strategy for the revised SERC vision and in defining how SERC research will address the key challenges DoD faces in building flexible, adaptable systems in an era of austere budgets and rapidly adapting adversaries. Direct participation in several research projects provided a new means of tapping this rich reservoir of experience.



SERC Research Council Members

Dr. Barry W. Boehm
***Chairman of SERC Research Council**; TRW Professor of Software Engineering and Director Emeritus, Center for Systems & Software Engineering, University of Southern California*

Dr. William Rouse
Professor and Executive Director of the Tennenbaum Institute for Enterprise Transformation, Georgia Institute of Technology

Dr. Abhijit Deshmukh
James J. Solberg Head of Industrial Engineering and Professor of Industrial Engineering, Purdue University

Dr. Jon Wade
Associate Dean for Research, School of Systems and Enterprises, Stevens Institute of Technology

Dr. Barry Horowitz
Munster Professor of Systems and Information Engineering and Chair, University of Virginia

Dr. Michael Griffin
Eminent scholar and Professor of Mechanical and Aerospace Engineering, The University of Alabama in Huntsville

SERC Research Activities Since 2008

Enterprises Systems and SOS

- Evolutionary Requirements for Net-Centric Enterprises
- System of Systems (SoS) Impact
- SoS Analysis

Trusted Systems

- SE Applied to Cyber Security
- Security Engineering Roadmap

SE and Management Transformation

- Analyzing Agile MPTs
- Rapid Graphical CONOPS Development
- Software-Intensive Systems Measurement
- Systems Maturity and Architecture Assessment
- Valuing Flexibility
- Integration of M&S, SW Design, and DoDAF
- Vehicle SE Requirements & Design Flexibility
- Agile-Lean Systems Engineering
- Expedited Systems Engineering
- SE Effectiveness Measures
- Reconfigurable Architecture for SE Knowledge
- Evolutionary Acquisition
- SE Transformation
- Verification, Validation & Accreditation
- DoD Systems 2020
- Communications and Effects Server
- Contingency Basing Projects
- The Cloud

Human Capital Development

- Body of Knowledge and Curriculum to Advance SE
- Technical Leadership Development
- SE Experience Accelerator
- STEM Capstone
- SE Assessment & Workforce Development

Annual SERC Research Review Addresses DoD Challenges

Nearly 160 people attended the 3rd Annual SERC Research Review on October 3-5, 2011 at the University of Maryland in College Park. In addition to current government sponsors and SERC collaborators, ASRR 2011 expanded its participation to include industry, PhD students, non-SERC collaborator schools, other University Affiliated Research Centers (UARCs) and potential new government sponsors.

The ASRR 2011 focused on the exchange of ideas among government and academic thought leaders regarding some of the most pressing and important research challenges faced by the DoD. It also provided an opportunity to share information between ongoing SERC research projects, and continued the collaboration among SERC researchers and government. The program included a variety of invited speakers, expert panels, and presentations by research teams and graduate students from the collaborators. Presentations are available at: **http://www.sercuarc.org/events/view/20**.

FEATURED SPEAKERS

- **Ms. Kristen Baldwin**, Principal Deputy, Deputy Assistant Secretary of Defense (Systems Engineering) [DASD(SE)]

- **Major General Nick Justice**, US Army – Commander of Army Research, Development & Engineering Command

- **Mr. Alfred Grasso**, President and CEO, MITRE Corporation

- **Colonel Lester Ogawa**, US Air Force – Chief, Engineering and Technical Management Division, Deputy Assistant Secretary of the Air Force for Science, Technology and Engineering

- **Ms. Victoria Cox,** Senior Vice President for NextGen and Operations Planning Services, Federal Aviation Administration

- **Mr. Nicholas Torelli,** Director of Mission Assurance, Office of Deputy Assistant Secretary of Defense (Systems Engineering)

PANELS

Resilient Systems

How should the systems engineering community respond to DoD's specific focus on engineered resilient systems?

Mr. Scott Lucero, chair [ASD(R&E)]. Panelists: Mr. Terry Edwards (USA(ALT)), Dr. Robert Hummel (Potomac Institute), Mr. Robert Keane (Ships USA), Dr. Janos Sztipanovits (Vanderbilt).

- Resilience means effectiveness in a wide range of situations, readily adaptable to others through reconfiguration or replacement, with graceful degradation of function
- A Common Operating Environment can be designed and implemented to provide resiliency
- Domain-specific design patterns are narrow but provide efficiency and effectiveness where applicable

Expedited SE

How can systems engineering be performed far more rapidly yet deliver full value?

Ms. Debra Facktor Lepore, chair (Stevens). Panelists: Mr. Richard Freeman (Center for Systems Engineering), Dr. Neil Siegel (Northrop Grumman), Dr. Ricardo Valerdi (University of Arizona)

- The social aspects (e.g. incentives, culture, language) are key barriers/enablers for expediting
- Reuse of artifacts (e.g. architectures, patterns, systems) can be a strong enabler
- Complexity drives need for more SE and cannot always be reduced or expedited

Model-Based SE

Is model-based systems engineering ready for major acquisitions?

Dr. William Rouse, chair (Georgia Tech). Panelists: Mr. Sanford Friedenthal (Lockheed Martin,), Dr. Leon McGinnis (Georgia Tech), Dr. Michael McGrath (ANSER), Mr. Walker Royce (IBM)

- MBSE continues to evolve and mature; NDIA and INCOSE major players
- Model-based Concept Engineering is a key leverage point for rapid fielding
- MBSE impacts all four dimensions of improving software economics: reducing complexity, increasing agility, improving collaboration, adding automation

Save the Date:

The 4th ASRR will be held November 13-15, 2012 at Georgetown University

Systems Engineering for an Agile and Lean World

Two new SERC research projects are working to bridge the gap between traditional systems engineering and the increasingly fast pace of system development.

Expedited Systems Engineering

This project, sponsored by the U.S. Air Force, is examining expedited systems engineering as applied to rapid capability for urgent needs developed in response to changing threats. The lifecycle of urgent needs programs is driven by "time to market" as opposed to complete satisfaction of static requirements, with delivery expected in days or months versus years or decades. The successful techniques seen in rapid prototyping must scale to larger, more complex, and supportable weapon systems. The systems engineering processes and practices applied to urgent needs must innovate conceptual solutions, quickly prune the design space, and choose good designs that can deliver suitable and efficient warfighting capability. And all of this requires the right people, in the right team, in the right organization, in the right environment.

The purpose of the research is to explore and develop a scalable expedited SE framework for hybrid programs, i.e., those exploiting rapid development, but with the intent to have traditional lifecycle considerations for deployment, maintainability, reliability, adaptability and sustainment. Likewise, as urgent becomes "normal," this new SE framework would be applicable to more traditional acquisition programs with a desire to incorporate scaled rapid development best practices.

The research began by conducting site visits with organizations practicing rapid development. The team interviewed individuals in defense, civil, and commercial entities to gain insight into the roles that people, process, and product (or architecture) play in these programs. The team is now synthesizing the data to develop an initial framework and select areas for deep dive research. The team will prepare a plan for validating the framework on a DoD acquisition program. Future phases anticipate executing this plan, with further research to analyze the framework in action and iterate it based on observations and results as applied to a real program.

The SERC Research Council is contributing to the early phases of the research by sharing their expertise and perspectives. This represents the first time the Research Council has actively engaged in a research task as a group, and we expect more engagement like this in other SERC tasks.

Debra Facktor Lepore
PI - Stevens Institute of Technology

Dr. John Colombi
Co-PI - Air Force Institute of Technology

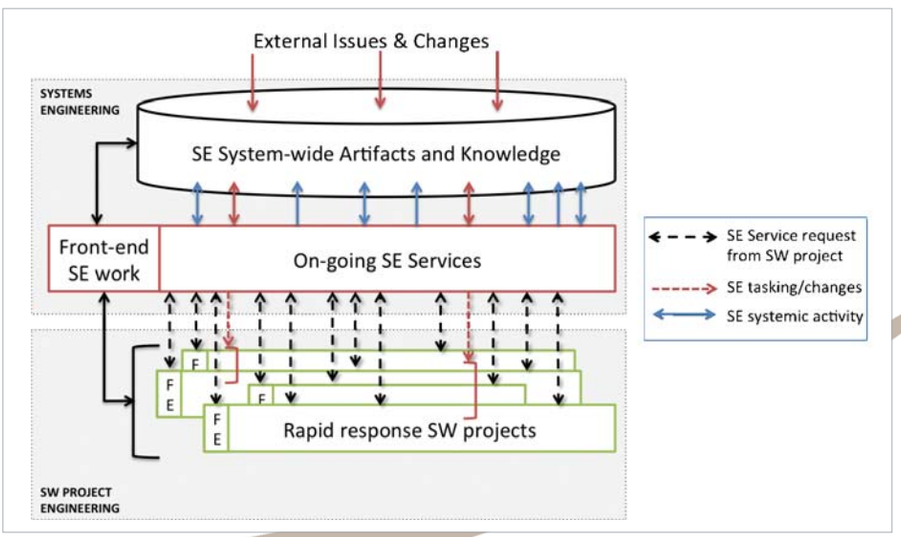
The Effectiveness of Kanban in Systems Engineering

This project is researching an unconventional approach that combines lean engineering concepts with a services approach to systems engineering to better integrate SE into rapid–response software application development for the intelligence community. Marrying the ideas of a services perspective with a lean-inspired pull scheduling technique such as kanban, is a radical departure from the normal concepts of systems engineering.

The reason for adopting it is the environment. In an environment where there is an existing complex system constantly evolving through rapid-response software application development, systems engineering is the glue that holds all of the various projects together. It is critical that it be integrated into the various projects without unduly delaying them, and that the limited resource of systems engineering skills be efficiently and effectively deployed so as not to unduly delay any particular project and still meet the overall system priorities. The services approach better integrates SE into the development cycle, and the kanban-based scheduling maximizes the value flow of the systems engineering tasks performed. This project is developing the combined approach and then simulating it with a hybrid of discrete event, continuous flow, and agent-based models and typical work streams to determine if the idea is sound enough to actually pilot in an operational environment.

Dr. Richard Turner
PI - Stevens Institute of Technology

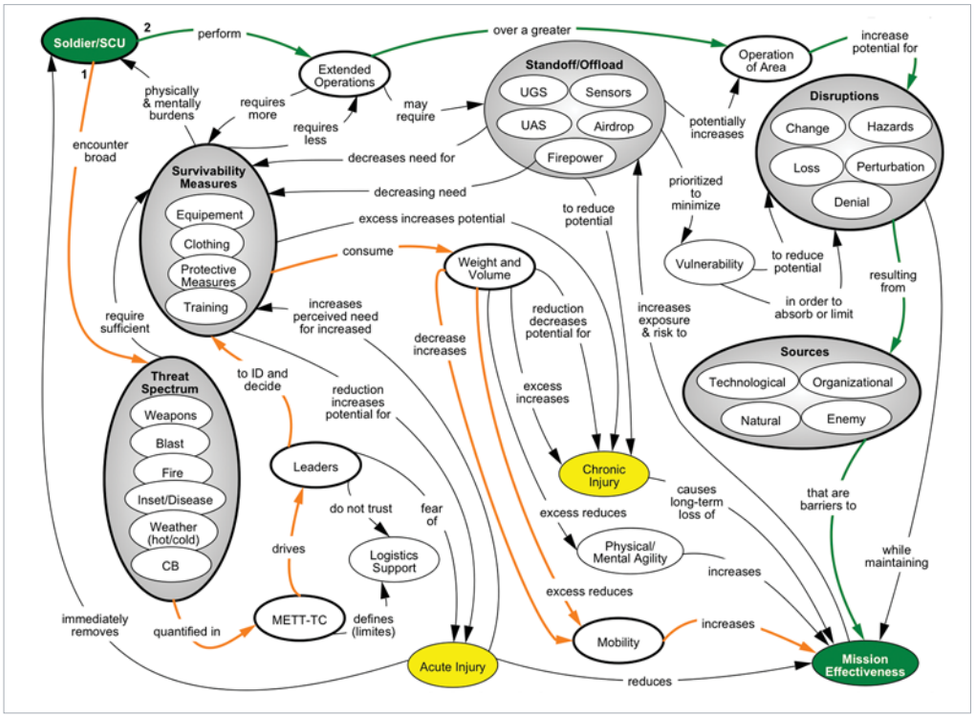
Dr. Ray Madachy
Co-PI - Naval Postgraduate School



Operations & Analysis in Complex, Dynamic Tactical Small Unit Contingency Basing

Sponsored by the U.S. Army, this research is focused on specific aspects of Tactical Small Unit-Contingency Basing (TSU-CB), as a force projection platform and a potential means to address the interrelated individual Soldier and TSU cognitive and physical load. The TSU exhibits a complex, pluralistic, set of requirements across a number of factors ill-suited to standard system engineering practices. The dynamic nature of TSU operations makes capturing, explaining, and managing the complex operational and system interactions difficult. The research task is developing a novel set of interrelated processes, mechanisms, tools, and measures to support optimizing TSU-CB operations and analysis.

One element of the research is examining graphical basing and soldier load prototyping to demonstrate emerging methods, processes, and tools. The objective is to develop collaborative and system models to express and characterize complex systems and system of systems. A first phase is to create a set of systemigrams (systemic diagrams). Systemigrams implement a systems thinking methodology using a graphical technique to understand and identify the significant elements within a system of interest, capture their interrelationships, and demonstrate in multiple and diverse expressions of stakeholder concerns and needs. Systemigrams enable the stakeholders to explore diversity in their perspectives while maintaining a single objective. A methodology is now being developed that can transition systemigrams to more a formal systems modeling language (i.e. SysML). The end state of this research is to have an approach that would provide a tailored methodology to create a system architecture that would provide stakeholders a mechanism to evaluate system of systems.



Desired Operational Outcomes

- Reduced human, systems, and information vulnerabilities and losses
- Reduced sustainment demands
- Cost effective choices and solutions
- Effectively trained, distributed and ready soldiers and planners with contingency basing skills
- Force multiplication effect from reduced Contingency Basing manpower burden on operational mission forces
- Reduced time, material, equipment and personnel requirements for Base Construction/ Deconstruction
- Enhanced interoperability informed by coalition partner practices with Joint, Inter-Agency, Inter-Governmental and Multi-National partners
- Reduced Environmental, Safety and Occupational Health Risks.

Dr. Brian Sauser
PI - Stevens Institute of Technology

Will Cloud Computing Transform SE?

This project is a rapid-turnaround (10 week) study motivated by the growing importance of cloud computing as an emerging technology paradigm. Conducted by researchers and faculty members from the Fraunhofer Center for Experimental Software Engineering at the University of Maryland, the University of Virginia, and Southern Methodist University, team members have experience in both the research on cloud computing topics as well as building cloud-based systems.

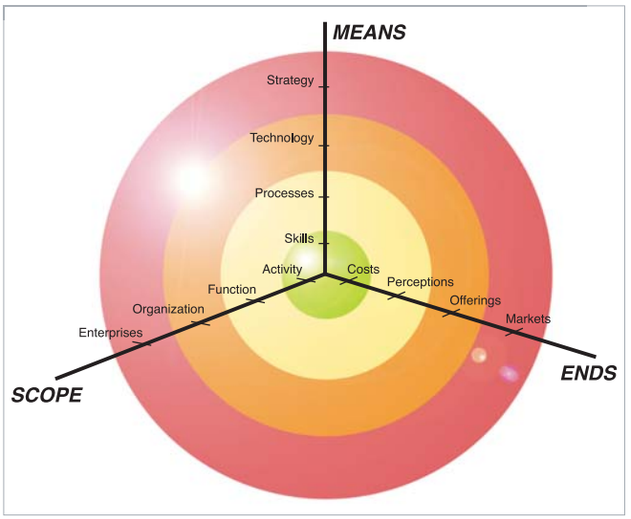
A Quick Response Study

The research examines the relationship between system engineering and cloud computing with respect to the following three questions:

1. How will cloud computing impact future systems? This involves forecasting the technology and computing opportunities enabled, as well as identifying risks to the US and its adversaries introduced by cloud computing.
2. How will cloud computing affect the discipline of system engineering? This addresses identifying the domain knowledge integral to cloud computing over time.

Progress Continues on a Net-Centric System Requirements Methodology

This task, performed by researchers from Georgia Tech and USC, uses case study analysis of business mergers and other types of information technology integrations to aid in the specification of a methodology to address the requirements management problem in net-centric enterprises.



Net-centric enterprises increasingly are found in government and industry contexts. In this research, a net-centric enterprise consists of a number of semi-autonomous organizations that collaborate within the context of a federated structure. Such collaborations may be temporary and of known duration, temporary and of unknown duration, or permanent and known to be permanent.

When such semi-autonomous organizations collaborate, they typically have information technology needs to support their collaboration. In the information technology (IT) domain, such needs are called requirements. From a business or organizational perspective, these needs are called capabilities or functions. In designing and developing IT systems to support high-level capabilities, capabilities are decomposed to functions and then to requirements. From requirements, software architectures are derived and then implemented. The fundamental problem is how to manage the process of proceeding from capabilities to systems, i.e., requirements management in the net-centric enterprise.

The preceding simple linear process description is useful, but inadequate to address the complexity of the net-centric enterprise. This complexity manifests itself in the following forms – the need to join existing IT systems belonging to the organizations involved in the collaboration to support the desired capabilities, the perhaps unknown durations of such collaborations, the presence of legacy systems, and the evolving needs and missions of the various organizations.

The fundamental problem is how to manage the process of proceeding from capabilities to systems, i.e., requirements management in the net-centric enterprise.

Dr. William Rouse
PI- Georgia Institute of Technology

Dr. Douglas Bodner
Co-PI - Georgia Institute of Technology

Dr. Nenad Medvidovic
Co-PI - University of Southern California

3. How can system engineers use cloud computing to advance system engineering? This suggests ways of exploiting cloud computing to improve the process of system conception, development, and maintenance.

The answers to these questions can provide direction for the advancement (or restructuring) of system engineering as a discipline, and may lead to the redefinition of roles, responsibilities and required skills.

The team found that cloud computing will have a transformative effect on systems and the systems engineering discipline. The cloud gives a large number of users access to virtually limitless resources through small portable devices and minimal local computing power. It also provides a way to harness those resources to develop and deploy systems more rapidly, but will require different approaches to traditional development activities. For example, the role of system engineers will change to focus less on traditional requirements elicitation and functional testing. Instead, user behavior and feedback must be monitored and collected to quickly adapt the features of the system to the user and resolve defects. Testing of qualities like security, performance, and especially privacy become more important, and more research is needed to define best practices for assuring them in a cloud environment.

Other technical findings address the increasingly important role of interfaces, challenges in releasing software updates without disrupting other cloud services, organizational issues such as the need for transparency in the cloud for policy reasons, and ongoing work on standards.

Dr. Chris Ackermann
PI - Fraunhofer Center

SERC Spearheads SE Workforce Development Enablers

The SERC has focused heavily on new technologies and innovative approaches to renew the SE workforce and prepare it for facing present and future systems development challenges. The following four research tasks provide examples of ongoing research.

Advancing the Discipline of Systems Engineering

The BKCASE™ Project, supported by the SERC, is defining the authoritative Systems Engineering Body of Knowledge (SEBoK) and developing a Graduate Reference Curriculum for Systems Engineering (GRCSE™). A group of more than 60 talented systems engineers from across the world has been working since September 2009 to incrementally build and release both SEBoK and GRCSE. Available as a wiki at **www.sebokwiki.org**, the SEBoK provides hundreds of articles describing the field of systems engineering, its structure and vocabulary, and pointing to the most important references in journals, books, standards, and websites. Impact from SEBoK is expected in many areas, such as affecting how INCOSE certifies practicing systems engineers. GRCSE, available as a PDF at **www.bkcase.org**, offers recommendations to faculty who are creating and updating graduate programs in systems engineering. Early impact of GRCSE is already apparent — several universities are using a draft of GRCSE in building their new graduate SE programs. BKCASE finishes at the end of 2012, when INCOSE and the IEEE Computer Society are expected to assume stewardship of both SEBoK and GRCSE, encouraging broad adoption and enabling regular updates.

Dr. Art Pyster
PI - Stevens Institute of Technology

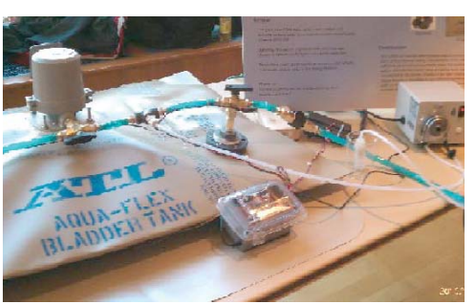
Dr. David Olwell
Co-PI - Naval Postgraduate School

Building Systems Engineering Education and Workforce Capacity

This project seeks to increase the SE workforce through the development and delivery of university-level capstone courses. The study focuses on increasing positive student experiences through course design, mentor support, real-world project topics, and the use of multi-disciplinary teams.

Student outcomes show improvements in SE and DoD problem awareness and an increase in interest in and appreciation of the field. Nine promising practices for the effective use of SE Capstone courses have been identified so far as a result of this study.

The first phase of the project encompassed a 20-month, three-phase effort from March 1, 2010 to October 31, 2011, including planning, course implementation, and analysis. Institutions were selected for participation through a competitive application process based on criteria developed in consultation with the sponsor.



During the 2010-11 academic year SE Capstone courses were developed and piloted in six military institutions and eight civilian universities affiliated with the SERC. Follow-on research includes six new schools partnering with six returning SERC schools and four military institutions this year.

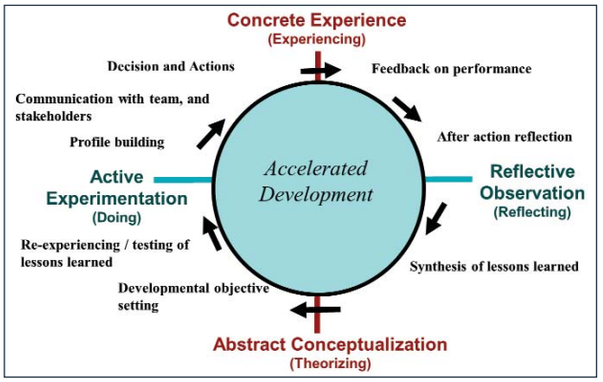
Four topic areas illustrating authentic DoD problems were presented for student teams' projects. Problem areas were selected, in part, based on expertise of participating faculty and institutional resources and on availability of DoD and local experts. Institutions organized their teams in different ways: the most common structure included several teams working on several different design problems.

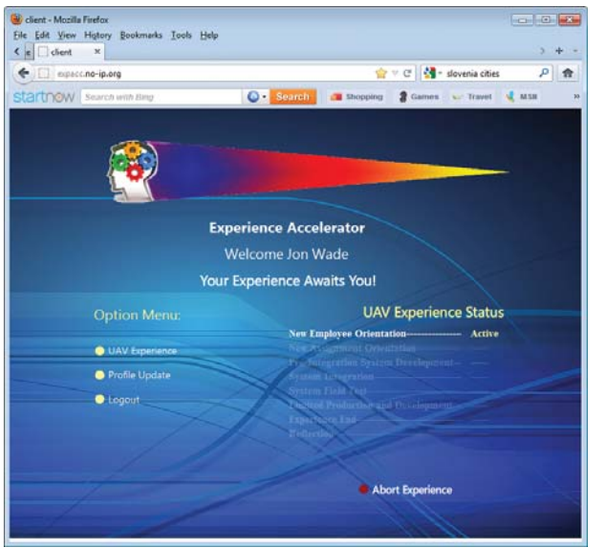
Approximately 360 students participated in the first year of the project. They were instructed by about 50 faculty and supported by more than 30 DoD and industry mentors. A similar number of students, faculty and mentors are engaged in projects this year. Several student teams are geographically distributed across different schools, providing a more realistic, and also more challenging environment.

Ms. Elisabeth McGrath
PI - Stevens Institute of Technology

Accelerating How Systems Engineers Learn & Mature

The Systems Engineering Experience Accelerator (SEEA) research project was initiated to validate the use of technology to create an experiential, emotional state in the learner coupled with reflective learning. This could effectively compress time and significantly accelerate the learning process of a systems engineer (SE) compared to the way it occurs naturally on the job. The project is testing the feasibility of a simulated approach for accelerating systems engineering competency development in the learner.





The SEEA helps learners learn from mistakes in an environment in which they can face challenges and make errors in a safe environment without any long term negative work-related outcomes. Learners must also receive clear and actionable feedback as the basis for reflection, subsequent skill practice and behavior change. Therefore, performance assessment and feedback are important aspects of the overall learning process.

In this experience, learners assume the role of a lead program systems engineer for development of a new unmanned aerial system. They must make an appropriate set of decisions and trade-offs at key points during the development lifecycle to keep the program on track. They must recover from problems in a number of areas, including system requirements, schedule, quality, cost and customer expectations. The acquisition program is represented in the simulation engine as a set of system dynamics simulation models that include such activities as sub-system development, system integration and system test.

Baseline year accomplishments include: defined project goals and success metrics, identified critical competencies and maturation points, created appropriate learning experiences, defined an open architecture, selected technologies, and developed and demonstrated a prototype.

Dr. Jon Wade
PI - Stevens Institute of Technology

Dr. William Watson
Co-PI - Purdue University

A Systems-focused Approach to Creating Technical Leaders

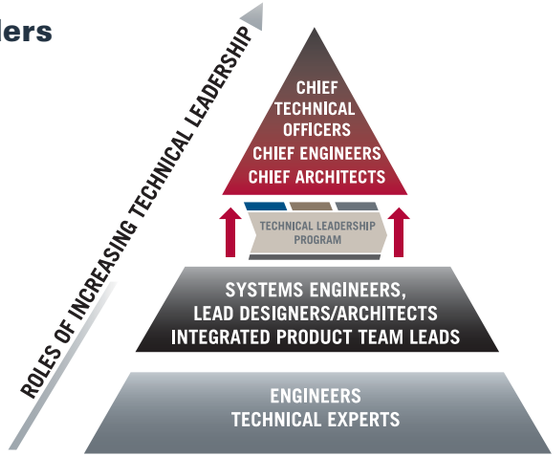
This research is helping DoD find ways to develop technical leaders, by focusing on leadership at the system level. Sponsorship from the Defense Acquisition University (DAU), is creating a technical leadership curriculum designed to immerse students into real-world situations requiring them to investigate the expanse of technical leadership. Considerations range from superior domain knowledge to those of personal and organizational effectiveness in order to develop recommended ways forward.

SYS 350A, the first of three technical leadership modules for DAU, focuses on systems. This pilot course provides insights into what to build and why, bringing solutions to life, ensuring systems work and are robust, and managing the evolution of a system. It covers topics such as technical uncertainty, applied systems thinking, leading others in creative problem solving, complexity, and why projects fail. Case studies were designed to give students real-world examples through which to explore these ideas, such as the Department of Homeland Security Container Security System and a process automation system in the telecommunications industry.

The first SYS 350A Systems Engineering Technical Leadership student pilot was conducted at the Aberdeen Proving Grounds Mission Training Center November 14-18, 2011. Twenty-two systems engineers from various Army installations with systems engineering experience ranging from 4 to 30+ years participated.

Feedback from the students has been very positive and included verbal statements such as, "This was real world," and, "I have seen this before in my job."

Future courses under development include the SYS 350B (business module) and SYS 350C (enterprise module) that expand the student's leadership experience into the broader technical and organizational domain demands of systems engineering leaders.



Dr. Valentin Gavito
PI - Stevens Institute of Technology

2011 SERC Advisory Board

The SERC Advisory Board is a select group of distinguished leaders with extensive experience in senior levels of government and the management of research organizations. Chaired by the Honorable Michael Wynne, the Board advises the SERC executive team on strategy and reviews SERC plans and progress.

The Honorable Michael Wynne, Chair Mr. Wynne is a senior advisor to Stevens Institute of Technology and serves as the Chair of the Advisory Board for the Systems Engineering Research Center. He was the 21st Secretary of the Air Force, and before that the Undersecretary for Acquisition, Technology and Logistics in the office of the Secretary of Defense, both spanning 2001 to 2008. He served in the Air Force for seven years, finishing as assistant professor of Astronautics at the Air Force Academy. He spent three years with Lockheed Martin Corp as the general manager for Space Launch, and 23 years with General Dynamics working in aircraft, armored vehicles, and the space division. He retired as senior vice president from General Dynamics.

Ms. Marion Blakey Marion C. Blakey is president and chief executive officer of the Aerospace Industries Association. AIA represents the nation's leading manufacturers and suppliers of civil, military, and business aircraft, helicopters, unmanned aerial vehicles, space systems, aircraft engines, missiles, materiel and related components, equipment services and information technology. Ms. Blakey became the eighth full-time chief executive of the association in 2007. Before that, she served a five-year term as administrator of the Federal Aviation Administration. Prior to being named FAA Administrator, Blakey served as chairman of the National Transportation Safety Board. Blakey served as administrator of the National Highway Traffic Safety Administration, and held key positions at the Department of Commerce, the Department of Education, the National Endowment for the Humanities, the White House, and the Department of Transportation.

Dr. Ruth David Dr. David is president and CEO of Analytic Services Inc. Prior to ANSER, she was Deputy Director for Science and Technology at the Central Intelligence Agency and was awarded the CIA's Distinguished Intelligence Medal, the CIA Director's Award, the Director of NSA Distinguished Service Medal, the NRO's Award for Distinguished Service, and the Defense Intelligence Director's Award. Dr. David is a senior fellow of the Defense Science Board, a member of the Department of Homeland Security Advisory Council, the National Security Agency Advisory Board, the Corporation for the Charles Stark Draper Laboratory, Inc., and the Hertz Foundation Board. She was elected into the National Academy of Engineering in 2002 and currently serves as a councilor of the NAE, chairs the National Research Council (NRC) Board on Global Science and Technology, chairs the NRC Standing Committee on Technology Insight–Gauge, Evaluate, and Review (TIGER), and is a member of the Standing Committee on Science, Engineering, and Public Policy (COSEPUP).

Mr. Alfred Grasso Mr. Alfred Grasso is president and chief executive officer of The MITRE Corporation. He is responsible for developing and leading the corporation's overall strategic and business operations and cultivating key sponsor and customer partnerships. Mr. Grasso is also a member of MITRE's Board of Trustees. Mr. Grasso is a member of the Defense Science Board, vice chair of the Armed Forces Communications and Electronics Association (AFCEA) International Board of Directors. He is a special advisor to the STRATCOM CYBER Strategic Advisory Group. Mr. Grasso is the president of the Board of Directors of the National GEM Consortium, a nonprofit that works to promote the participation of under-represented groups in science, technology, engineering, and mathematics (STEM) careers.

Dr. Michael Griffin Michael Griffin, one of the world's leading aerospace engineers and the 11th NASA Administrator, is currently an eminent scholar and a professor of mechanical and aerospace engineering with The University of Alabama in Huntsville. Dr. Griffin served as chief engineer and as associate administrator for exploration at NASA, and as deputy for technology at the Strategic Defense Initiative Organization. He is the lead author of more than two dozen technical papers, as well as the textbook, "Space Vehicle Design." A registered professional engineer in Maryland and California, Griffin is an Honorary Fellow of the American Institute of Aeronautics and Astronautics (AIAA), a Fellow of the American Astronautical Society, and a Senior Member of the Institute of Electrical and Electronic Engineers. He is a recipient of the NASA Exceptional Achievement Medal, the AIAA Space Systems Medal, and the Department of Defense Distinguished Public Service Medal, the highest award given to a non-government employee.

Mr. John G. Grimes Mr. Grimes served as the Assistant Secretary of Defense for Networks and Information Integration / Department of Defense Chief Information Officer from 2005 until 2009. Prior to that, he served on the White House National Security Council Staff as Director for National Security Telecommunications Policy; Director of Defense Command, Control and Communications Programs; and Senior Director White House Situation Support Staff. Mr. Grimes has served as Deputy Assistant Secretary of Defense for Defense-wide Command, Control and Communications and was the Deputy Assistant Secretary of Defense for Counterintelligence and Security Countermeasures. He is the recipient of the AIAA Command, Control, Communications and Intelligence Award, the 2010 AFCEA SARNOFF Award, and two U.S. Presidential Rank awards.

SYSTEMS ENGINEERING
Research Center

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The SERC offices are located at
Stevens Institute of Technology
The Babbio Center
Hoboken, NJ 07030
Phone: 201-216-8300

www.SERCuarc.org

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Hoboken, NJ 07030
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